Global Scientific JOURNALS

GSJ: Volume 8, Issue 5, May 2020, Online: ISSN 2320-9186
www.globalscientificjournal.com

Temperature and Humidity affect on the virus infectivity

HadirGawili[1]*, Huda A Mohamed[2], Abdelmetalab F Tarhuni[2],RimaHAli [2], Amal A Mukhtad[3]

[1] Department of Environmental Health, Faculty of Public Health, University of Benghazi,Benghazi, Libya
[2]Department of Environmental Health, Faculty of Public Health, University of Benghazi, Benghazi, Libya
[3] Department of Environmental Health, Faculty of Public Health, University of Benghazi, Benghazi, Libya

Email address:

Hadir.gawili@uob.edu.ly (H.Gawili)

***Corresponding author**

Abstract

COVID -19 is the most infection disease (Coronavirus disease) caused by a recently discovered virus. Air exchange rate, outdoor climate, weather conditions and occupant behavior are the main factors affect the indoor air quality and the rate of virus spread as these factors leading to increasing the virus spread according to many researches. However, data on survival of this virus is require on environmental surfaces and on how survival is affected by environmental variables such as air temperature (AT) and relative humidity (RH). And as a cool dry environment is being the most favorable condition for its transmission and either warm or humid conditions being unfavorable. Other environmental factors should be considered are wind velocity, daily sunlight, and air pressure, these factors had shown to be associated with SARS epidemic.

Keywords: COVID-19, virus, temperature, humidity, environmental factors.

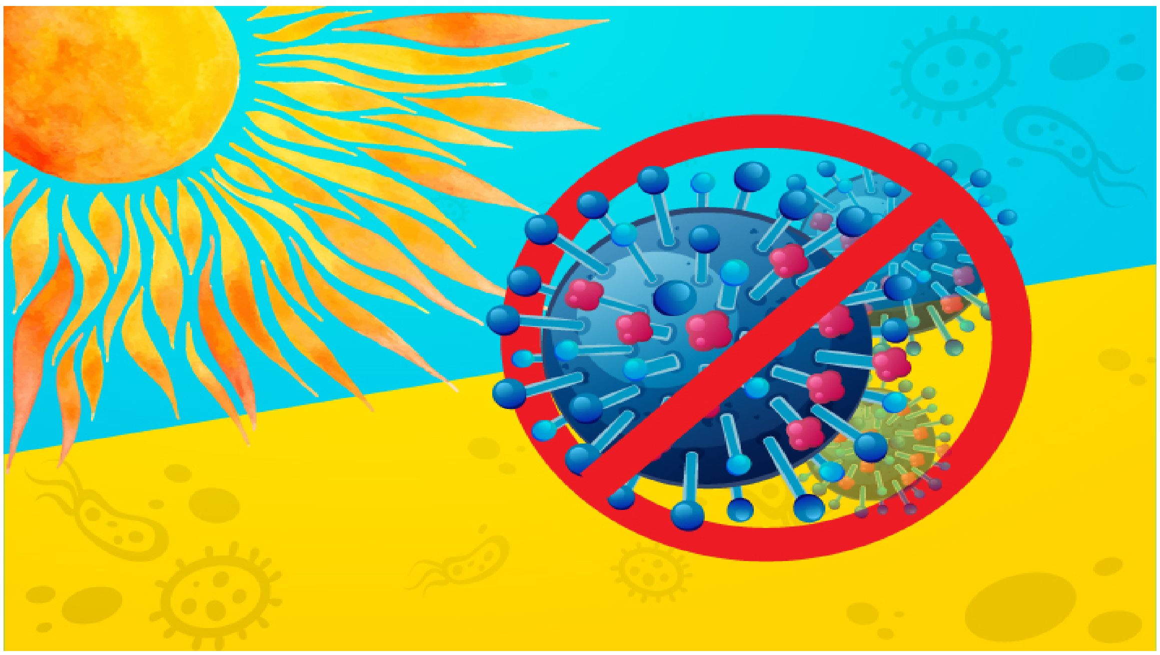
Background review:

Recently, Coronavirus is spreading around the whole world, and this let several countries to think about the necessary precautions that are needed to decrease the chances of getting infection with this virus. Coronavirus is same to other germs, viruses, and pollutant that people need to combat in the homes. Therefore, this report is focus on viruses and germs that are spread through a central Heating, Ventilation, and Air Conditioning HVAC system. Since One-way people can be proactive and protect themselves from getting sick in general is by being educated on Indoor Air Quality (IAQ)[1] .

There are Several factors affect indoor air quality, including the air exchange rate, outdoor climate, weather conditions, and occupant behavior.

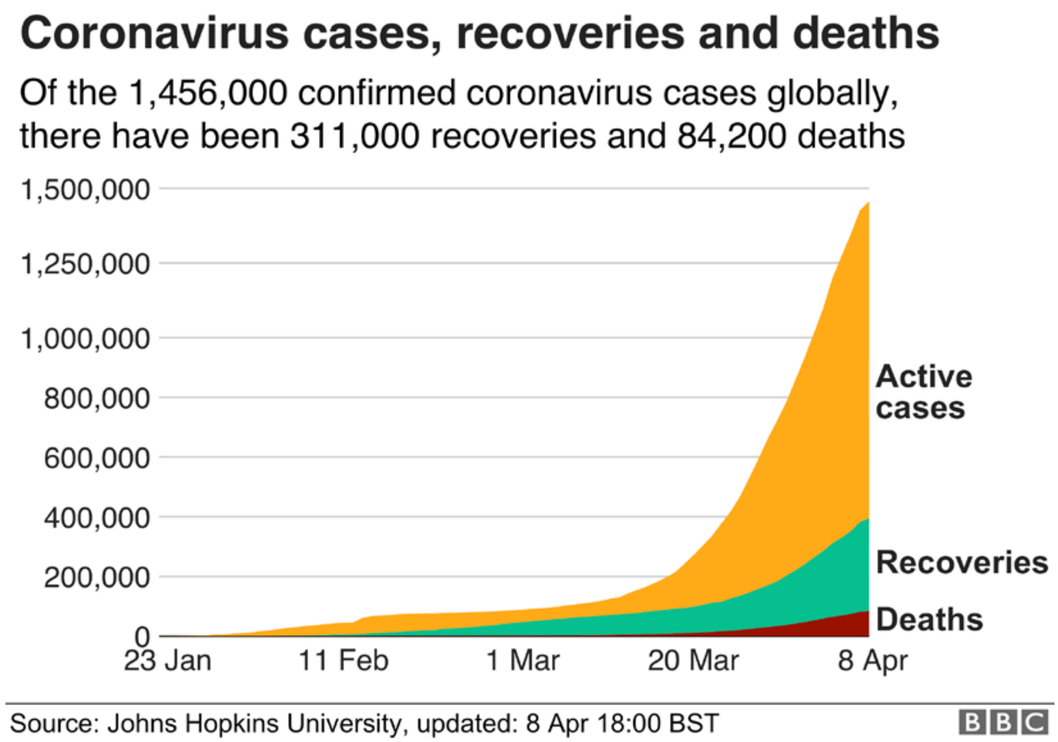
Firstly, The air exchange rate ofthe outdoors is considered as an essential factor in determining indoor air pollutant concentrations. The air exchange rate is affected by the design, construction, and operating parameters of buildings and it is ultimately a function of infiltration (air that flows into structures through openings, joints, and cracks in walls, floors, and ceilings and around windows and doors), natural ventilation (air that flows through opened windows and doors), and mechanical ventilation (air that is forced indoors or vented outdoors by ventilation devices, such as fans or air handling systems).

Furthermore, Outdoor climate and weather conditions are combined with occupant behavior, can affect indoor air quality. Weather conditions influence whether building occupants keep windows open or closed and whether they operate air conditioners, humidifiers, or heaters, all of which can affect indoor air quality. Also, Certain climatic conditions can increase the potential for indoor moisture and mold growth if not controlled by adequate ventilation or air conditioning[2].



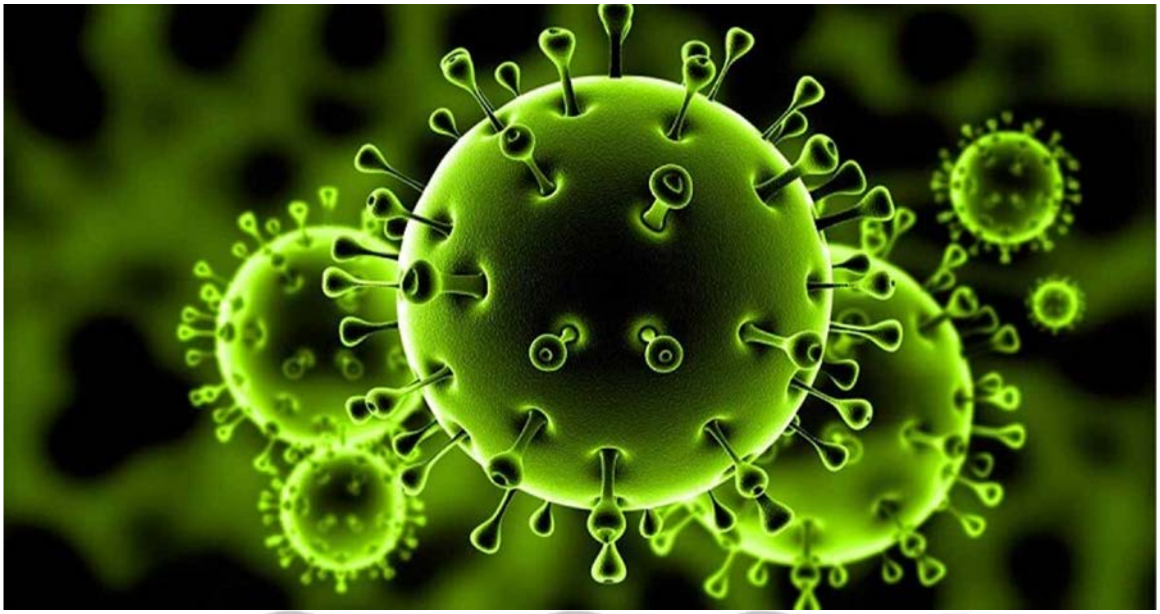
Coronavirus disease 2019 (COVID-19)

Thereare a large family of viruses that cause diseases ranging from the common cold like flu to more severe diseases. A novel coronavirus (nCoV) is a new strain that has not been previously identified in humans and has spread throughout China to several countries, and it leads to increase the mortality rate around worldwide[3].



https://www.bbc.com/news/world-51235105

Coronaviruses are enveloped RNA viruses of the Coronaviridae virus family and Human coronaviruses (HCoV) has two known serogroups designated OC43 and 229E, these two serogroupsare responsible for up to one-third of common colds[4]. and it could be associated with more serious diseasessuch as hospital-acquired upper respiratory tract infections in premature newborns with apnoea and bradycardia[5].Prevention of such hospital-acquired infections is based on knowledge of the mode of transmission. The route of entry of HCoV appears to be the nasal mucosa since common colds can be produced after intranasal inoculation of healthy volunteers [6,7]Infection via the conjunctival mucosa, as described for respiratory syncytial virus (RSV), has not been demonstrated for HCoV. Horizontal transmission via small particle aerosols is theoretically possible because airborne HCoV-229E has previously been shown to survive for as long as 86 h under controlled temperature and humidity conditions(8).



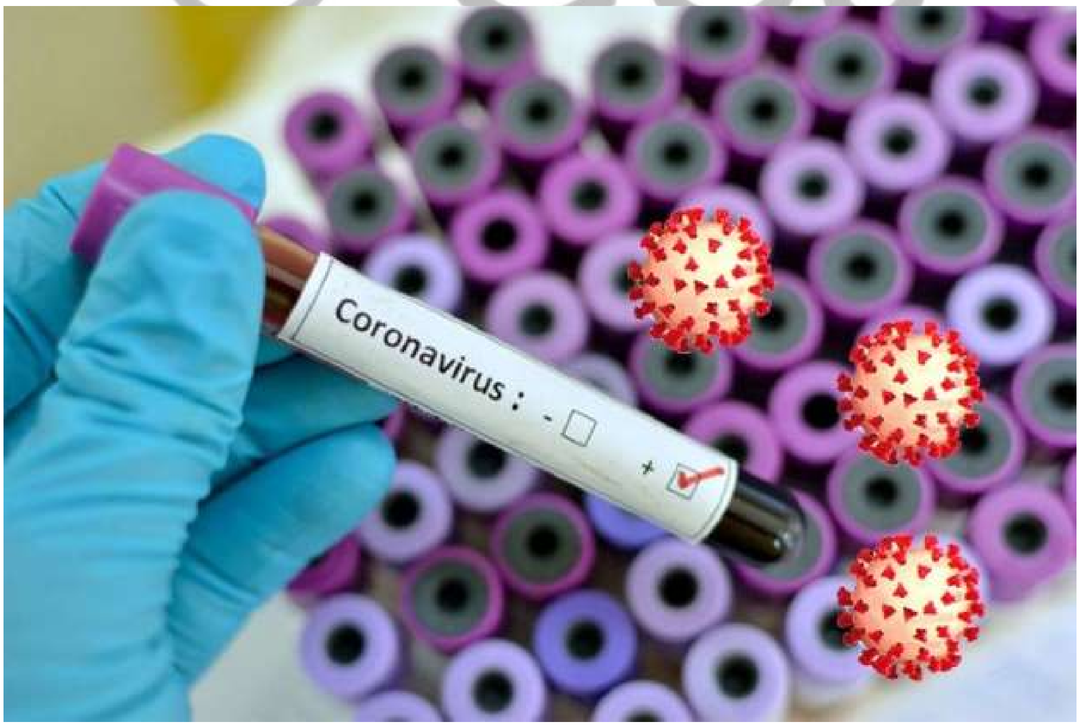
https://www.nrttv.com/AR/News.aspx?id=23737&MapID=6

These Viruses do not replicate outside living cell but infectious virus may persist on contaminated environmental surfaces and the persistence durationof viable virus is affected markedly by temperature and humidity. Contaminated surfaces are known to be significant vectors in the transmission of infections in the hospital setting as well as the community. The role of fomites in the transmission of RSV has been clearly demonstrated(9).

There are several scientific researches studies the effects of temperature and humidity on the coronavirus. According toCasanova et al. 2010, the risk assessment posed by severe acute respiratory syndrome (SARS) coronavirus (SARS-CoV) on surfaces requires data on survival of this virus on environmental surfaces and on how survival is affected by environmental variables, such as air temperature (AT) and relative humidity

(RH).Infectious virus persisted for as long as 28 days, and the lowest level of inactivation occurred at 20% RH. Inactivation was more rapid at 20°C than at 4°C at all humidity levels; and these viruses persisted for 5 to 28 days, and the slowest inactivation occurred at low RH. Both viruses were inactivated more rapidly at 40°C than at 20°C[10].

Also, another study reported that the stability of human coronavirus infectivity was maximum at pH 6.0 when incubated at either 4 or 33 °C. However, the influence of pH was more pronounced at 33 °C. Viral infectivity was completely lost after a 14-day incubation period at 22, 33, or 37 °C but remained relatively constant at 4 °C for the same length of time. Finally, the infectious titer did not show any significant reduction when subjected to 25 cycles of thawing and freezing. This study will contribute to optimize virus growth and storage conditions, which will facilitate the molecular characterization of this important pathogen[11].



In 2013, Doremalen et al. studies the stability of Middle East respiratory syndrome coronavirus (MERS-CoV)at three different degrees of temperature and humidity; 20°C – 40% relative humidity (RH); 30°C – 30% RH and 30°C – 80% RH. It reported that MERS-CoV was more stable at low temperature/low humidity conditions and could still be recovered after 48 hours. Also, there no decrease in stability was observed at 20°C – 40% RHduring aerosolisation of MERS-CoV. These data suggest the potential of MERS-CoV to be transmitted via contact or fomite transmission due to prolonged environmental presence(12).

TABLE

Decay of Middle East respiratory syndrome coronavirus (MERS-CoV) on plastic and steel surfaces at different temperatures and percent humidity

Surface type; temperature, relative humidity	Mean half-life time of MERS-CoV (hours)[a]	Standard deviation
Plastic; 20°C, 40%	0.954523	1.110443
Plastic; 30°C, 30%	0.441822	0.345291
Plastic; 30°C, 80%	0.904005	4.6838
Steel; 20°C, 40%	0.940139	1.837771
Steel; 30°C, 30%	0.973656	0.31109
Steel; 30°C, 80%	0.641163	0.825395

[a] Mean half-life was determined from three independent experiments.

Furthermore, influenza A virus it is shown that transmission is associated with the viability of the virus under different environmental conditions, such as temperature and humidity, and a cool dry environment is being the most favorablecondition for its transmission and either warm or humid conditions being unfavorable(13).

In 2011, Astudy was conducted to evaluate the stability of MERS-CoV (isolate HCoV-EMC/2012) under three different environmental conditions; high temperature and low humidity (30°C – 30% relative humidity (RH)), high temperature and high humidity (30°C – 80% RH) and low temperature and low humidity (20°C – 40% RH)that reflect an indoor environment.It observed that stability of MERS-CoV under the three tested environmental conditions was respectively compared in aerosols at 20°C with 40% or 70% RH was also assessed and compared(14).

While there is very little scientific research on the effects of temperature on Corona virus, a study was published in the journal Advances of Virology in 2011 looked at the transmission of SARS-CoV that had emerged from China in 2003 and its relation to temperature and humidity,The research showed that the virus was more stable at low temperature and low humidity environments, which could facilitate its transmission in air-conditioned environments(15).

Others have reported that infectivity of SARS CoV (SARS coronavirus) was lost after heating at 56°C for 15 minutes but it was stable for at least 2 days following drying on plastic. It was completely inactivated by common fixatives used in laboratory(16)(17).

On the other hands, another study reported that SARS CoV can survive for at least two weeks after drying at temperature and humidity conditions found in an air-conditioned environment. Furthermore, virus can be stable for 3 weeks at room temperature in a liquid environment but it is easily killed by heat at 56°C for 15 minutes(16).

Additionally, an experimental studied the The stability of the virus at different temperatures and relative humidity on smooth surfaces, thevirus was dried then incubated at different temperatures (38°C, 33°C, 28°C) at different relative humidity (>95%, 80~89%) for 3 hr, 7 hr, 11 hr, 13 hr, and 24 hr and the residual viral infectivity was titrated. It found that the dried virus can retained its viability at temperatures of 22-25°C and relative humidity of 40-50% for over 5 days that is considered as typical air-conditioned environments (Figure 1), after that that the virus infectivity is gradually lost every time. However, its viability was rapidly lost at higher temperatures (38C) and higher relative humidity (95%). On the other hand, The best stability of this virus was observed at low temperature and low humidity environment.[15].

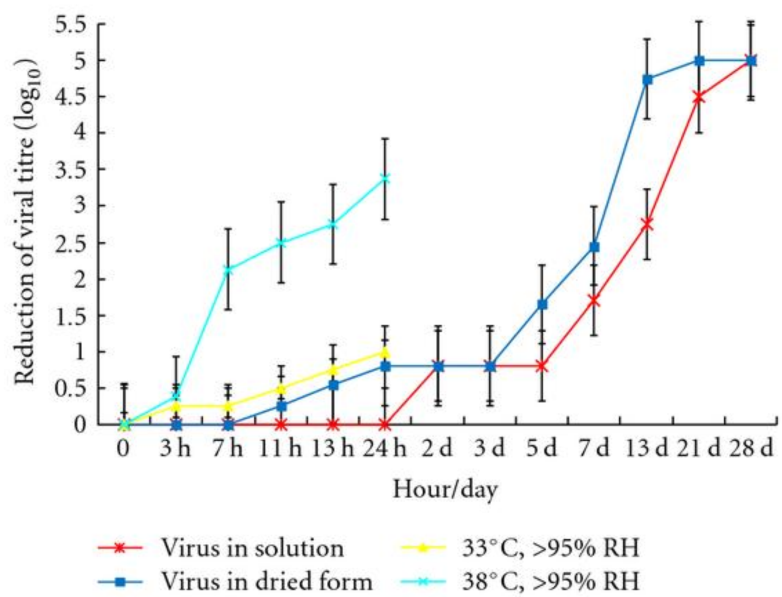


Fig1. Residual virus infectivity at 22–25°C with relative humidity 40–50% (starting titre 105/10 μL) and at 33°C or 38°C with relative humidity >95%.

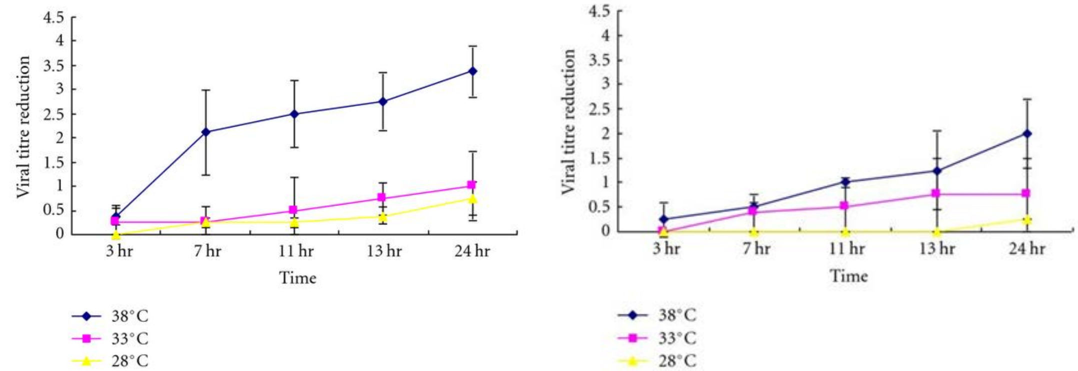


Fig2: Infectivity of SARS Coronavirus (105/10 μL) to different temperatures at (a) >95% relative humidity, (b) >80–89%.

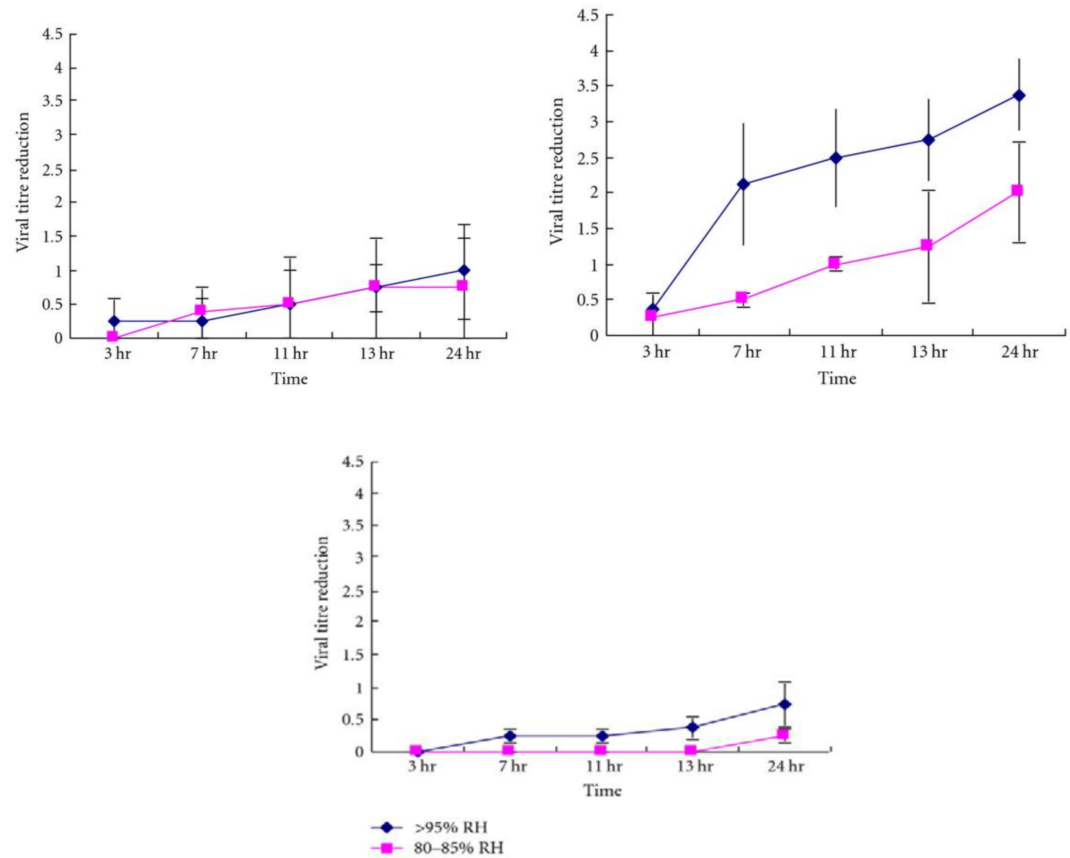


Fig3:Infectivity of SARS Coronavirus (starting titre 105/10 μL) at different relative humidity at (a) 38°C, (b) 33°C, and (c) 28°C.

These observations may explain why some Asian countries in tropical area (with high temperature at high relative humidity) such as Malaysia, Indonesia, and Thailand did not have nosocomial outbreaks of SARS (Tables 1 and 2(a)–2(c)). Also, it may explain why Singapore, which is also in tropical area, had most of its SARS outbreaks in hospitals (air-conditioned environment)(see table 2(d))[18].

Interestingly, during the outbreak of SARS in Guangzhou, clinicians kept the windows of patient rooms open and so the rooms are well ventilated and these may well have reduced virus survival and reduced nosocomial transmission. Conversely, SARS CoV can retain its infectivity up to 2 weeks at low temperature and low humidity environment, which might facilitate the virus transmission in community as in Hong Kong which locates in subtropical area (Table 2(e)). Other environmental factors including wind velocity, daily sunlight, and air pressure, had shown to be associated with SARS epidemic, should also be considered[18][19].

Table 1

WHO SARS report—based on data as of the 31st December 2003.

Areas	Total	Medan age	Deaths	Case fatality Ratio (%)	No. of imported Cases (%)	No. of HCW (%)	First case	Last case
China	5327	NKn	349	7	NA	1002 (19)	Nov-02	Jun-03
Hong Kong	1755	40	299	17	NA	386 (22)	Feb-03	May-03
Taiwan	346	42	37	11	21 (6)	68 (20)	Feb-03	Jun-03
Singapore	238	35	33	14	8 (3)	97 (41)	Feb-03	May-03

Viet Nam	63	43	5	8	1 (2)	36 (57)	Feb-03	Apr-03
Indonesia	2	56	0	0	2 (100)	0 (0)	Apr-03	Apr-03
Malaysia	5	30	2	40	5 (100)	0 (0)	Mar-03	Apr-03
Thailand	9	42	2	22	9 (100)	1 (11)	Mar-03	May-03
Philippines	14	41	2	14	7 (50)	4 (29)	Feb-03	May-03
Total	8096		774	9.6	142	1706 (21)		

Table 2

A summary of the meteorological data of 2005 in average weather conditions*.

Month	Average sunlight (hours)	Temperature		Discomfort from heat and humidity	Relative humidity	
		Min	Max		am	pm
(a) Kuala Lumpur, Malaysia						
Jan	6	22	32	High	97	60
Feb	7	22	33	High	97	60
March	7	23	33	High	97	58
April	6	23	33	High	97	63
May	6	23	33	High	97	66
June	7	22	33	High	96	63
July	7	23	32	High	95	63
Aug	6	23	32	High	96	62
Sept	6	23	32	High	96	64

GSJ: Volume 8, Issue 5, May 2020
ISSN 2320-9186

Oct	5	23	32	High	96	65
Nov	5	23	32	High	97	66
Dec	5	22	32	High	97	61
			(b) Jakarta, Indonesia			
Jan	5	23	29	High	95	75
Feb	5	23	29	High	95	75
March	6	23	30	High	94	73
April	7	24	31	High	94	71
May	7	24	31	High	94	69
June	7	23	31	High	93	67
July	7	23	31	High	92	64
Aug	8	23	31	High	90	61
Sept	8	23	31	High	90	62
Oct	7	23	31	High	90	64
Nov	6	23	30	High	92	68
Dec	5	23	29	High	92	71
			(c) Bangkok, Thailand			
Jan	9	20	32	High	91	53
Feb	8	22	33	High	92	55
March	9	24	34	High	92	56
April	8	25	35	Extreme	90	58
May	8	25	34	Extreme	91	64
June	6	24	33	Extreme	90	67
July	5	24	32	High	91	66
Aug	5	24	32	High	92	66

Sept	5	24	32	High	94	70
Oct	6	24	31	High	93	70
Nov	8	22	31	High	92	65
Dec	9	20	31	High	91	56

(d) Singapore

Jan	5	23	30	High	82	78
Feb	7	23	31	High	77	71
March	6	24	31	High	76	70
April	6	24	31	High	77	74
May	6	24	32	Extreme	79	73
June	6	24	31	High	79	73
July	6	24	31	High	79	72
Aug	6	24	31	High	78	72
Sept	5	24	31	High	79	72
Oct	5	23	31	High	78	72
Nov	5	23	31	High	79	75
Dec	4	23	31	High	82	78

(e) Hong Kong

Jan	5	13	18	—	77	66
Feb	4	13	17	—	82	73
March	3	16	19	—	84	74
April	4	19	24	Medium	87	77
May	5	23	28	Medium	87	78
June	5	26	29	High	86	77
July	8	26	31	High	87	77

Aug	6	26	31	High	87	77
Sept	6	25	29	High	83	72
Oct	7	23	27	Medium	75	63
Nov	7	18	23	Moderate	73	60
Dec	6	15	20	—	74	63

In summary, some epidemiologic analysis, experimental studies, and airflow simulations support the probability of an airborne spread of this virus.

Measures require the identification of cases and contacts of persons with COVID-19 and recommended assessment, monitoring, and care of travelers arriving from areas with substantial COVID-19 transmission. Although these measures might not prevent widespread transmission of the virus, it provides time to better prepare state and local health departments, health care systems, businesses, educational organizations, and the general public in the event that widespread transmission occurs; and better characterize COVID-19 to guide public health recommendations and the development and deployment of medical countermeasures, including diagnostics, and therapeutics needed.

If sustained transmission in communities is identified strategy, it will enhance implementation of actions to slow spread in communities. However, studies have shown that early layered implementation of these interventions can reduce the community spread and impact of infectious pathogens such as pandemic influenza, even when specific pharmaceutical treatments and vaccines are not available[20][21].

The Federation of European Heating, Ventilation and Air Conditioning Associations (REHVA) has published guidelines on how building services in areas with a coronavirus outbreak should operate to minimize the spread of the infection.

REHVA is currently updating COVID-19 guidance document. The following new recommendations are under preparation:

1. Recommendation of regenerative heat exchangers (rotors) is under change, to consider the leakage and pressure difference between exhaust and supply side. The leakage via rotor, carrying over also particles, may increase from the limit of the standard of 5% to 15% if fans create higher pressure on the exhaust air side. Evidence suggest that rotors with adequate purge sector do not transfer particles, but the transfer is limited to gaseous pollutants. Because the leakage does not depend on the rotation speed, it is not needed to switch rotors off. If needed, the pressure differences can be corrected by dampers or by other arrangements.
2. Additional evidence will be added to the question of relative humidity. SARS-CoV-2 stability (viability) has been tested at typical indoor temperature of 21-23 °C and RH of 65% with very high virus stability at this RH. Together with previous evidence on MERS-CoV, it is well documented that humidification up to 65% may have very limited or no effect on stability of SARS-CoV-2 virus. Therefore, the evidence does

not support that moderate humidity (RH 40-60%) will be beneficial in reducing viability of SARS-CoV-2, thus the humidification is NOT a method to reduce the transmission and spread of SARS-CoV-2.

According to many researches that recommended;

1. In the apartment should use opening window a bit for air exchange and have out door entering the room andkeep opening for at least 15 minutes before somebody enters, especially if it was occupied by others., to decrease coronavirus transmission.

2. Using central air conditioning system could transmit coronavirus to all the spaces it conditions if return air is used. Central air conditioning systems is recommended 100 per cent outside air.

3. Should buildings switch on ventilation systems round the clock, or at least extend the operation of ventilation systems as much as possible.

4.Ventilation rates should be switched to low power when people are absent in order to remove virus particles out of the building. Exhaust ventilation systems of toilets should be kept on 24/7.

5. Such places should not keep windows in toilets open as it will encourage contaminated airflow from the toilet to other rooms.

Reducing risk of respiratory disease, practice recommended preventive measures. Ill people with symptoms of COVID-19 who have had contact with a person with COVID-19 or recent travel to countries with apparent community spread, should communicate with their health care provider. Before seeking medical care, they should consult with their provider to make arrangements to prevent possible transmission in the health care setting. In a medical emergency, they should inform emergency medical personnel about possible COVID-19 exposure.

The role of fomites and environmental contamination in virus transmission may play a significant role in virus transmission. In particular, fomites may contribute to the continued transmission of infection in the nosocomial setting that continues to occur in spite of the great attention and stringent precautions taken to prevent droplet spread. In addition to droplet precautions, reinforcing contact precautions and hand washing [22]

References:

1. Public Health Response to the Coronavirus Disease 2019 Outbreak — United States, February 24, 2020
2. U.S. Environmental Protection Agency. 1997. Exposure factors handbook volume 3: Activity factors. EPA/600/P-95/002Fa. Washington, DC.
3. World Health Organization. 2020. Coronavirus Disease (COVID-2019) R&D.
4. Myint SH. Human coronavirus infections. In Siddell SG, ed. The Coronaviridae. New York: Plenum Press, 1995; 389–401.
5. Sizun J, Soupre D, Giroux JD et al. Nasal colonization with coronavirus and apnea of the premature newborn. Acta Paediatr 1993; 82: 238.
6. Bradburne AF, Bynoe ML, Tyrrell DAJ. Effects of a new human respiratory virus in volunteers. Brit Med J 1967; 3: 767–769.
7. Larson HE, Reed SE, Tyrrell DAJ. Isolation of rhinovirus and coronaviruses from 38 colds in adults. J Med Virol 1980; 5: 221–229.
8. Ijaz MK, Brunner AH, Sattar SA et al. Survival characteristics of airborne human coronavirus 229E. J Gen Virol 1985; 66: 2743–2748.
9. C. B. Hall, R. G. Douglas, and J. M. Geiman, “Possible transmission by fomites of respiratory syncytial virus,” Journal of Infectious Diseases, vol. 141, no. 1, pp. 98–102, 1980.
10. Casanova LM, Jeon S, Rutala WA, Weber DJ, Sobsey MD. 2010. Effects of air temperature and relative humidity on coronavirus survival on surfaces. Appl Environ Microbiol 2010; 76:2712–2717. doi:10.1128/AEM.02291-09.
11. Lamarre A, Talbot PJ. Effect of pH and temperature on the infectivity of human coronavirus 229E. Can J Microbiol 1989; 35: 972–974.
12. Doremalen N, Bushmaker T, Munster V J. Stability of Middle East respiratory syndrome coronavirus (MERS-CoV) under different environmental conditions. Euro Surveill. 2013;18(38):pii=20590.
13. Steel J, Palese P, Lowen AC. Transmission of a 2009 pandemic influenza virus shows a sensitivity to temperature and humidity similar to that of an H3N2 seasonal strain. J Virol. 2011;85(3):1400-2.

14. Safronetz D, Rockx B, Feldmann F, Belisle SE, Palermo RE, Brining D, et al. Pandemic swine-origin H1N1 influenza A virus isolates show heterogeneous virulence in macaques. J Virol. 2011;85(3):1214-23.

15. Chan KH, Peiris JS, Lam SY, Poon LL, Yuen KY, Seto WH. The Effects of Temperature and Relative Humidity on the Viability of the SARS Coronavirus. Adv Virol. 2011;2011:734690.

16. WHO Report, "First data on stability and resistance of SARS coronavirus compiled by members of WHO laboratory network," http://www.who.int/csr/sars/survival_2003_05_04/en/#

17. M. Y. Lai, P. K. Cheng, and W. W. Lim, "Survival of severe acute respiratory syndrome coronavirus," Clinical Infectious Diseases, vol. 41, no. 7, pp. e67–e71, 2005.

18. J. Yuan, H. Yun, W. Lan et al., "A climatologic investigation of the SARS-CoV outbreak in Beijing, China," American Journal of Infection Control, vol. 34, no. 4, pp. 234–236, 2006.

19. Q. C. Cai, J. Lu, Q. F. Xu et al., "Influence of meteorological factors and air pollution on the outbreak of severe acute respiratory syndrome," Public Health, vol. 121, no. 4, pp. 258–265, 2007.

20. Hatchett RJ, Mecher CE, Lipsitch M. Public health interventions and epidemic intensity during the 1918 influenza pandemic. Proc Natl Acad Sci U S A 2007;104:7582–7.

21. Markel H, Lipman HB, Navarro JA, et al. Nonpharmaceutical interventions implemented by US cities during the 1918–1919 influenza pandemic. JAMA 2007;298:644–54.

22. Jernigan DB. Update: Public Health Response to the Coronavirus Disease 2019 Outbreak — United States, February 24, 2020. MMWR Morb Mortal Wkly Rep 2020;69:216–219.
DOI: http://dx.doi.org/10.15585/mmwr.mm6908e1